A SYNOPSIS

On

"GREEN SYNTHESIS OF NANO-PARTICLES AND THEIR APPLICATION AS ANTIMICROBIALAGENTS AGAINST PLANT PATHOGENS"

Submitted

by

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INTRODUCTION

In recent years, the agricultural industry has faced significant challenges in combating plant pathogens, which are disastrous for agriculture productivity and food security. The excessive use of synthetic pesticides and antibiotics has not only led to environmental pollution but also caused the appearance of strains of plant pathogens that are drug-resistant. This infact necessitated exploration of alternative, eco-friendly strategies to combat plant diseases effectively. One such promising approach is the utilization of nanoparticles synthesized through green methods as antimicrobial agents plant pathogens.

Nanotechnology, with its remarkable advancements, has revolutionized various sectors, including agriculture. Nanoparticles are ultra-small structures, typically ranging from 1 to 100 nanometers and for their size and more surface-to-volume ratio, they possess favourable physicochemical features. These properties make them attractive for diverse applications, including agriculture. The synthesis of nanoparticles using eco-friendly methods, often referred to as green synthetic pathway, gained a great deal of attention recently because of its sustainability and reduced environmental impact compared to conventional synthesis techniques.

The green fabrication of nano-particles involves utilizing various biological resources such as plants, bacteria, fungi, and algae, which behave as stabilizers and help in reduction process during the fabrication. This approach eliminates the need for hazardous chemicals and energy-intensive processes typically associated with traditional nanoparticles synthesis methods. Moreover, the use of natural resources in nanoparticles synthesis promotes the concept of waste valorization and sustainable utilization of bioresources.

Antimicrobial activity against plant pathogens is of the most promising uses of green-synthesized nanoparticles in the field of agriculture. Plant pathogens, including bacteria, fungi, and viruses, are responsible for causing diseases that affect the growth, development, and yield of crops worldwide. The ability of nanoparticles to exhibit potent antimicrobial activity against these pathogens has opened up new possibilities for effective disease management.

Green-synthesized nanoparticles possess several inherent properties that contribute to their antimicrobial potential. Firstly, the small size and large surface area of nanoparticles allow them to interact more effectively with microbial cells, leading to enhanced penetration and disruption of the cell membrane. Secondly, nanoparticles exhibit unique physicochemical properties, such as high surface reactivity and catalytic activity, which enable them to generate reactive oxygen species (ROS) upon interaction with microbial cells. ROS are highly toxic to microorganisms and can cause oxidative stress, ultimately leading to their death. Additionally, nanoparticles can interfere with the microbial DNA, RNA, and protein synthesis, disrupting vital cellular processes.

Furthermore, the broad-spectrum antibacterial efficacy of green-synthesised nanoparticles against plant pathogens offers a significant advantage over conventional pesticides and antibiotics, which often target specific pathogens and can lead to the emergence of resistant strains. The multi-modal action of nanoparticles, involving physical disruption, ROS generation, and interference with cellular processes, reduces the likelihood of resistance development, making them potential alternatives for sustainable disease management in agriculture.

The utilization of green-synthesized nanoparticles as antimicrobial agents against plant pathogens not only offers promising results but also addresses the growing concerns regarding environmental sustainability and human health. The use of eco-friendly synthesis methods and natural resources reduces the ecological footprint associated with conventional synthesis techniques. Moreover, nanoparticles synthesized through green methods are generally non-toxic to humans, indicating their potential for safe agricultural applications.

AgNPs are among one of the very extensively studied and broadly used nanoparticles because of their unique properties and versatile applications. AgNPs possess remarkable antimicrobial properties, making them highly efficient against a plethora of pathogens, likevirus, fungi, and bacteria. Their unique properties facilitate their interaction with microbial cells, leading to cell membrane disruption, DNA damage, and oxidative stress. These interactions ultimately result in the inhibition of microbial growth and proliferation. Additionally, AgNPs exhibit excellent stability, biocompatibility, and low toxicity to humans and the environment, making them

promising candidates for various implications in medicine, agriculture, and in remediating the environment. The green synthesis of AgNPs with help of microorganisms, plant extracts or other eco-friendly methods has gained significant attention as a sustainable alternative to conventional synthesis techniques. The unique properties and antimicrobial activity of AgNPs make them a potential tool for combating plant pathogens and enhancing crop protection in agriculture.

Zinc nanoparticles (ZnNPs) have also emerged as a promising nanomaterial with diverse applications in variety of fields that includes medicine, electronics as well as agriculture. ZnNPs exhibit unique physicochemical properties due to their small size and large surface area, which make them highly reactive and offer potential advantages in different applications. In the medical field, ZnNPs have shown antimicrobial, anti-inflammatory, and wound-healing properties, making them valuable for the development of novel therapeutics and biomaterials. In electronics, ZnNPs are utilized for their excellent electrical and optical properties, enabling their integration into electronic devices and sensors. In agriculture, ZnNPs have gained attention for their potential as nutrient carriers, delivering zinc to plants and improving their growth and productivity. Furthermore, ZnNPs possess antimicrobial properties, making them effective against plant pathogens, such as bacteria and fungi. The green synthesis of ZnNPs using environmentally friendly methods offers a sustainable approach to produce these nanoparticles, reducing the environmental impact associated with conventional synthesis techniques. Overall, ZnNPs hold great promise in different applications, and futureinvestigation is warranted to exploit their full potential and optimize their synthesis for specific uses.

The synthesis of nanoparticles using plants, also known as plant-mediated or green synthesis, has gained significant attention as an eco-friendly and sustainable approach in nanotechnology. Plants offer a vast array of bioactive compounds, such as polyphenols, flavonoids, alkaloids, and proteins, which are used in the manufacture of nanoparticles as capping agents, reducing agents andstabilisers, and. The process of plant-enhanced synthesis typically involves the selection of suitable plants and their parts (leaves/stems/flowers/ seeds) which are collected to be processed to obtain plant extracts. These extracts are then mixed with metal precursor solutions containing metal salts, such

as silver nitrate (AgNO3), Zinc nitrate or other metal ions. The bioactive compounds in the plant extracts facilitate the biological reduction of metalic ions into nano sized particles through various redox reactions. The reaction conditions, involving temperature, pH, and incubation time, play an important role in controlling size, shape as well as properties of the synthesized nano-particles. The methods for characterizing like X-ray diffraction (XRD), UV-Vis Spectroscopy, Fourier-transform infrared spectroscopy (FTIR) and transmission electron microscopy (TEM) are commonly employed to analyze and confirm the successful synthesis of nanoparticles. Plant-assisted synthesis provides several advantages over conventional synthesis methods. It being a sustainable and cost-effective approach reduces involvements for hazardous chemicals and energy-intensive processes associated with traditional methods. Additionally, the utilization of plant extracts promotes waste valorization and the sustainable utilization of bioresources. The bioactive compounds available in plant extracts not only help in reduction process but also provide stability to the synthesized nanoparticles. Furthermore, the nanoparticles obtained through plant-mediated synthesis exhibit biocompatibility and reduced toxicity, making them suitable for various applications, including biomedicine, catalysis, agriculture, and environmental remediation. Continued research in plant-mediated synthesis aims to explore new plant sources, optimize synthesis conditions, and develop functionalized nanoparticles with enhanced properties and performance. The synthesis of nanoparticles using plants holds great promise for sustainable nanotechnology applications, offering a greener and more environmentally friendly alternative in the field of nanoscience.

In the present research a plant named *Celosia cristata* willbe used. Celosia cristata, commonly known as cockscomb or crested celosia, is a flowering plant that belongs to the Amaranthaceae family. Apart from its ornamental value, *Celosia cristata* has been traditionally used in various cultures for its medicinal properties.*Celosia cristata* plant extract is a antimicrobial activities (Antibacterial and antifungal). These plants are disease resistant and their bacterial infection, fungal infection. Several studies have investigated the potential health benefits associated with this plant, revealing its diverse medicinal properties. This plant is found throughout Africa, South, America, India and some regions of Asia. The three components of flowers are called spikes, plumes, and

crests. Flowers come in a variety of hues; the most popular ones are red, yellow, orange, and pink. This plant contained vitamins B1, B2, C, and E as well as alkaloids, amino acids, carbs, gum, protein, steroids, saponins, and flavonoids. was traditionally used to treat uterine bleeding, hemorrhoids, bloody stools, burns, leucorrhoea, amenorrhea, hyperactive liver, dysentery, and leucorrhea (Singh & Kumar, 2019)[17]. *Celosia cristata* shows antimicrobial activity against pathogenic microbes like*Salmonella typhimurium,E. coli, Bacillus subtilis, Staphylococcus aureus,Pseudomonas aeruginosa* and*Candida albicance*(Sharma & Sharma, 2021)[16].

It may be concluded that, the green fabrication of nanoparticles and their application as anti-microbial agents for plant pathogens represents a novel and eco-friendly approach for sustainable disease management in agriculture. The unique properties of nanoparticles, combined with their broad-spectrum antimicrobial activity, make them highly promising candidates for future applications. Further research is required to explore the potential of different nanoparticle types and their optimization for specific plant pathogen control. This synopsis aims to investigate the green synthesis of nanoparticles and evaluate their effectiveness in combating plant pathogens, with below mentioned objectives.

REVIEW OF LITERATURE

Nanoparticles are a diverse spectrum of materials with dimensions under 100 nm, and because of their numerous properties, they are employable in many fields, such as the mechanical, medicinal, manufacturing, pharmaceutical, and materials, environmental, electronics, and energy collecting. Silver and Zinc nanoparticles are created by plant extracts and developed into acceptable antibacterial agents for agriculture are two examples of the metallic nanoparticles whose remarkable qualities have led to the development of several approaches for their synthesis. These programs are regarded as low-investment procedures that enable avoiding harmful by products and boostagricultural activities.

Issue of developing bacterial multidrug resistance can be greatly reduced by the use of nanoparticles, which are thought to be viable alternatives to antibiotics (Jackson *et al*., 2018)[5].Silver nanoparticles have long been used as an antiseptic and an antibacterial to treat different infections. The environmentally friendly production of zinc as well as silver nanoparticles assisted by plant extracts and their application as antimicrobials in agriculture to fight microbial infections that are responsible for waterborne, soilborne, and foodborne illness in plants. Numerous plant extracts have been processed and reported to have potential antibacterial activity against bacteria and fungi plant diseases (Jan *et al*., 2020)[8]. Through electrostatic attraction and sulphur affinity proteins, silver nanoparticles attach with the component of cell wall and cytoplasmic membrane of microbes, thereby damaging and inhibiting the microbes deactivating their respiratory enzymes, by production of reactive species, and interruption of adenosine triphosphate.

The creation of new drugs in the form of nanomaterials or in conjunction with antibiotics already on the market to provide a positive synergistic effect has also become necessary due to the rapidly increasing prevalence of microbes resistant to currently available antibiotics, leading to the widespread use of nanoparticles in various medical fields. However, it is impossible to consider these traditional methods an environmentally friendly procedure because they use expensive and harmful chemicals. The manufacture of metal and metal oxide nanoparticles using a biogenic approach, which used aqueous

plant extract and bacteria, has recently attracted the attention of researchers because it is an environmentally benign, stable, therapeutically adaptive, biocompatible, and economically advantageous process (Vanlalveni*et al*., 2021)[21]. About 650 different species of disease-causing microbes can be killed by silver, an inorganic antibacterial agent that is harmless and safe. The optical property of metallic nanoparticles, which is supported by localised surface plasmon resonance, is what gives them their therapeutic effectiveness. The unique chemical, biological, and physical properties of silver nanoparticles (AgNPs), that include a variety of actions like antifungal, antiviral, anti-inflammatory properties, and anticancer effects, make them among the most frequently used nanoparticles of metal in industry and biomedicine. The efficiency of silver nanoparticles in biological systems is influenced by surface chemistry, dimensions, distribution of size, form, nanoparticle shape, particle arrangement, covering accumulation, and dissolving rate (Widatalla*et al*., 2022)[23]. Several additional metabolites, such as sugars, alkaloids, flavonoids, phenolic acids, and terpenoids, originated from plant extracts have been used in tailoring or bio-reduce ionic silver metal into nanoparticles to be used as antibacterial activated carbon fibre in water treatment (Jiang *et al*., 2022 &Panhwar*et al*., 2022)[10,14]. Silver and zinc are made from a plant extract using a simple, environmentally friendly green synthesis process. UV-Vis measurement and the reaction mixture's colour shift both served as primary indicators of the silver nanoparticles production. silver nanoparticles morphological characteristics, such as their spherical form and poly-dispersed nature, were identified using SEM, TEM, and AFM analysis, while bio molecules associated with their reduction, stabilisation, and capping were identified in the FTIR spectrum (Rudrappa*et al*., 2022)[15].

RESEARCH GAP

According to the present scenario the ecofriendly synthesis of nanoparticles is an area of active research and they have been used in combating various plant pathogens. But still the organisms under study ie. *Fusarium spp.*, *Alternaria spp.* and *Xanthomonas spp.* are amongst one of the devastating organisms causing economic loss due to their pathogenic nature and diverse host range.

These are the pathogens of concern for which even after lot of investigation there is a gap of novel formulations which may help in combating with them and lower the losses caused by them in fields.Moreover the plant used in the study to synthesize nanoparticles has been seen to synthesize nanoparticles and have promising antimicrobial activity. But it is been unexplored for its potential activity against the organisms under study in its nano-formulation.

OBJECTIVES OF THE STUDY

1. To determine ability of *Celosia cristata* to produce nanoparticles (Zinc and Silver Nanoparticles)
2. To optimize effect of various parameters (concentration, temperature, pH, extracting time, etc.) for nanoparticles synthesis.
3. To synthesis nanoparticle under optimize conditions.
4. To characterize the synthesized nanoparticles by using spectrophotometer, FTIR, X-Ray Diffraction and transmission electron microscopy techniques.
5. To isolate and characterize the pathogenic microorganism (*Fusarium graminearum,Alternaria solani* and *Xanthomonas oryzae*)
6. To determine antimicrobial activity of the synthesized nanoparticles against plant pathogen.
7. To estimate minimum inhibitory concentrations as well as minimum bactericidal and fungicidal concentration of nanoparticles.

MATERIALS AND METHODS

1. Collection of the plant sample (*Celosia cristata*)

Celosia cristata flower and leaves will be collected from the field in Meerut and will be washed in running water. The wash flower and leaves will be air dried and then crushed to obtain fine powder which will be stored until further used.

2. Preparation of aqueous extract

20 gm of flowers and leaves powder *Celosia cristata* will be dispersed in 100 ml of sterile distill water and mix with the help of vortex and boiled for one hour at 80ºC. Then the flower extract will be collected in separate conical flasks and filtered with the help of standard filtration method (Verma *et al.*, 2017)[22].

3. Synthesis of *Celosia cristata* flower and leaves extract with silver nitrate

A solution of silver nitrate ($AgNO_3$) with a concentration of 10^{-3} M will be prepared. 5 ml of herbal extracts will be individually transferred into BOD bottles, and then combined with 95 ml of the prepared $AgNO_3$ solution. The extract is added to the aqueous $AgNO_3$solution will be regarded as the initiation of the reaction. Color change of the reaction mixture from yellow to dark brown will be an indication of the silver nanoparticles synthesis. (Verma *et al.*, 2017)[22].

4. Synthesis of *Celosia cristata* flower and leaves extract with Zinc nitrate

In the procedure 5 ml of the aqueous herbal extract will be added to 10^{-3}M zinc nitrate which was then heated between 60 °C to 90 °C. It will be possible to see the reaction mixture's color change from clear white to yellow. The reaction mixture's colorwill change from clear white to yellow, indicating that ZnO NPs have been produced. (Ahmad & Kalra, 2020)[1].

5. Optimization of conditions for silver nitrate and zinc nitrate production.

5.1 The impact of concentrations of zinc nitrate and silver nitrate on the production of nanoparticles.

10 ml silver nitrate and 10 ml zinc nitrate will be taken in three different tubes at different concentration (1mM, 2mM and 3mM) in which 2 ml of herbal plant extract will be added. Periodically, the solution's color change will be seen (Verma *et al.*, 2017)[22].

5.2 **Effect of different concentrations of *Celosia cristata* flower and leaves extracts.**

To silver nitrate and zinc nitrate (10 ml each) taken in different tubes, different volumes of extract (2ml, 4ml and 6 ml) will be added. The color change of the solution will be checked periodically (Verma *et al.*, 2017)[22].

5.3 Effect of different radiations on nanoparticles synthesis

To 2 ml of *Celosia cristata* extract, 10 ml of zinc nitrate and 10 ml of silver nitrate solution will be added in separate vessels. The mixture will then be exposed to UV and sunlight under various conditions. The solution color will be observed. (Verma *et al.*, 2017)[22].

5.4 Effect of different temperatures

2 ml of *Celosia cristata* extract will be added to 10 ml of silver nitrate and 10 ml of zinc nitrate solution in different containers, and will then be exposed to various temperatures, including (5°C, 25°C, 45°C, and 90°C). The creation of silvernanoparticles will be indicated by the extract of *Celosia cristata* flower and leaves changing from yellow to dark brown in color. When the extract from *Celosia cristata* flowers and leaves turns from white to yellow, it will besynthesized zincnanoparticles (Verma *et al.*, 2017)[22].

5.5 Effect of different pH

10ml of 1mM silver nitrate solution and zinc nitrate solution in three containers will be different pH solution like 5, 7 and 9. Every container 2ml of *Celosia cristata* flower and leaves extract will be added. The color change of the reaction mixture will be observed (Verma *et al.*, 2017)[22].

6. Characterization of synthesis of nanoparticles.

6.1 Visual observation: The color of the reaction mixture will change visibly following the treatment of leaf extract with silver nitrate solution and zinc nitrate solution (1 mM). The time taken for the reaction mixture's color to change will be observed (Verma *et al.*, 2017)[22].

6.2 UV-Vis Spectrophotometric analysis: In the analytical process of UV-Vis spectroscopy, the wavelengths of UV or visible light that are absorbed by or transmitted through a sample are measured. The characterization of nanoparticles can be greatly aided by UV-Visible spectrophotometer. Due to their intense visible surface plasmon resonance absorption and high sensitivity to surface change, new metal particles make excellent candidates for examination using UV-Vis spectroscopy. For the purpose of detecting silver nanoparticles (200–500 nm) and zinc oxide nanoparticles (300–400 nm), aliquots of the reaction mixture will be measured for absorbance using a UV–visible spectrophotometer (Verma *et al.*, 2017)[22].

6.3 Characterization by FTIR: The surface adsorption of functional groups on biosynthesis-derived nanoparticles was investigated using Fourier transform infrared spectroscopy. The Fourier transform infrared (FTIR) spectrometer will be used to analyse freeze-dried synthesised nanoparticles at 500–4000 cm^{-1}. To categories the biomolecules in the plant extracts around the nanoparticles (Jan *et al*., 2020)[8].

6.4 Characterization by XRD:XRD analysis will be accomplished to determine the crystalline structure, phase purity, and average crystallite size of nanoparticles synthesized (Mani *et al*., 2021)[12].

6.5 Characterization by TEM: Thesize of the synthesized nanoparticles will be confirmed using Transmission Electron Microscope (Verma *et al.*, 2017)[22].

7. Isolation of microorganism from Soil sample.

The microorganisms (*Fusarium graminearum*, *Alternaria solani*and *Xanthomonas oryza*)) will be isolated from soil and infected plant samples using standard serial dilution agar plating method and will be identified on the basis of various morphological and biochemical characteristics.

7.1 Collection of sample and isolation of microbes

Samples will be collected from multiple field locations in Meerut where the host plants are been grown in sterile containers or polythene bags with proper labeling. The samples will be processed as per standard protocol of serial dilution agar plating method and will be placed on suitable medium (Nutrient agar and Potato dextrose agar).

7.2 **Identification of Microbes**

Morphological

Morphology (*Fusarium spp*.)

Fusarium species are large filamentous fungi. Colonies are rapidly expanding, light or brightly coloured, and either have or lack a cottony aerial mycelium, Macroconidia andMicroconidia from slender phialides. Chlamydospores present or absent in *Fusarium spp*.

Morphology (*Alternaria spp.*)

Alternaria spp are group of Ascomycete fungi and are saprophytic in natureColonies range in color from floccose to suede-like black, olivaceous black, or grey. Long, dark brown chains of conidiophores are present. Conidia develop on conidiophores, and the enormous, dark spores that they produce are fine long septa and with short beaks.

Morphology (*Xanthomonas spp*.)

Xanthomonas spp. is a Gram-negative, aerobic, short rod-shaped bacterium. Family-Pseudomonadaceae. Colonies are yellow pigmentation and viscosity aerobic, motile and nonsporulating. Size – 0.4 – 1.0 µm, wide by 1.2 – 3.0 µm long Motility – motile by a single polar flagellum. Temperature range- 4 to 37 °C.

Biochemical identification

Catalase: Positive

Oxidase: Negative

Sequence based identification by DNA Barcoding method

In DNA barcoding method, the sequence of the isolates will be compared to a sequence database and species will be identified on the basis of similarity between the sequences present in various databases.

8. Antimicrobial activity of phyto silver and Zinc Oxide nanoparticles.

Agar well diffusion method will be used to measure the antimicrobialactivity of synthetically made zinc oxide and silver nanoparticles. Gel puncture will be used to create 5 mm-diameter wells on nutritional agar plates. Theinoculums of different test microbes will be adjusted according to 0.5 McFarland standard and the antimicrobial activity will be determined by using agar well diffusion method(Jain*et al.,* 2015)[6].With the aid of an L-shaped glass spreader, each strain will be evenly distributed onto the different plates. The sample nanoparticle solution (10 µl, 20 µl and 50 µl)) will be pipetted into each well on each plate at various concentrations using a micropipette. The distinct zones of inhibition will be assessed following a 24-hour incubation period at 37°C (Verma *et al.*, 2017)[22].

The result will be concluded according to Clinical and Laboratory Standards Institute (CLSI) guidelines.Fungi *Fusarium graminearum*(MTCC 2089) *Alternaria solani*(MTCC 10690) and Gram-negative bacteria *Xanthomonas oryzae* (MTCC 11107) strain will be used as a positive control.

9. Minimum Inhibitory Concentration (MIC)

The Minimum Inhibitory Concentration of the antimicrobials will be determined by the method involving microdilution in culture broth. An indicator solution will be prepared by dissolving one tablet of resazurin dye in 40 ml of sterile water. 0.1 ml of nutrient broth will be poured and labelled onto a micro-titer plate. Then, after adding 0.1 ml of the nanoparticle solution to the first well, the various nanoparticles will be serially diluted by adding 0.1 ml of the solution to subsequent wells. Each well will receive an equal addition of a test bacteria broth culture grown overnight in nutrient broth. Each well will have a label, and an equal volume of indicator solution (0.1 ml) will be added one at a time. The sterile control solution was made up of indicator solution and sterile broth, whereas the growth control solution was made up of indicator solution and broth culture. The microtitre tray will next be incubated for six hours at 37°C. Pink solution indicated growth inhibition in test wells, while blue represented the opposite (Verma *et al.*, 2017)[22].

10. Minimum Bactericidal and Fungicidal Concentration (MBC/MFC)

Minimum Bactericidal/Fungicidal Concentration to kills 99.9% of microorganism. The MBC and MFC assays have been effective tools for evaluating the simultaneous bactericidal activity of a number of antimicrobial drugs, frequently for screening purposes. Finding the Minimum Bactericidal Concentration (MBC) and Minimum Fungicidal Concentration (MFC) of an agent is frequently done after the MIC test.We culture all clear tube in MIC, and start from the first dilution at which no growth was observed, the culture by taken (0.1 ml) for all clear tube and incubate 16-18 hrs. After incubation period, we observed the plate, which do not contain growth, so this plate is MBC, which kill growth of microorganism.

11. Statistical Analysis.

All experiments will be performed in triplicate. Statistical analysis of the data will be performed using Statistical Software for Social Sciences (SPSS). A p value <0.05 regarded as significant.

IMPACT OF PROPOSED RESEARCH

The term "nanotechnology" typically refers to a branch of applied science and technology whose overarching goal is to manipulate matter at the atomic and molecular level. Because of their distinct characteristics and prospective uses in plasmonics, optoelectronics, biological sensors, and medicinal applications, metal nanoparticles have drawn a lot of attention in recent years.Their size, shape, and composition have a significant impact on how well they perform. Metal nanoparticles can be created chemically, however many of the reactants and starting elements are poisonous or otherwise dangerous for biological uses. As a result, a variety of biological synthesis techniques that produce nanostructures have been documented employing bacteria, fungi, and plants(Lekha *et al*., 2021)[11].The fact that inorganic nanoparticles are created by biological systems makes them more biocompatible and environmentally benign.

Many exciting uses of these environment-friendly nanoparticles such as antibacterial activity, cytotoxicity against tumorous cells, wound healing, protein-specific binding of sugar-capped nanoparticles and other applications makes their biosynthesis using plant extracts potentially exciting for the large-scale synthesis of metallic and other inorganic nanomaterials. The uses of nanoparticles in less-explored avenues such as protein interactions and purification, molecular tracking etc. are interesting future prospects of this technology.

In the treatment of numerous infectious diseases as well as epidemiological procedures, the emergence of bacterial strains resistant to antibiotics and antimicrobial agents poses a severe concern. It will be necessary to take steps to stop the growth and spread of multiresistant strains of bacteria as well as to create new antibacterial chemicals in order to combat bacterial resistance. The ability of plant extracts to be used as precursors for syntheses of SNPs having plant antimicrobial activity appears new potential. It has also given a critical momentum to the field of nanotechnology to exploit its potential in field of agriculture, making a way for the development of novel fungicide and antibacterial new therapeutic agents.

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